MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

DCA5068 – FIELD THEORY

(Diploma in Electronic Engineering)

12 MARCH 2019
9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 4 pages excluding the cover page with 4 Questions only.

2. Attempt **ALL (4)** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Find an expression for the unit vector directed toward the origin from an arbitrary point on the line described by $x = 2$ and $z = 2$. [5 marks]

(b) We use arrows to demonstrate the spatial variation of a vector field, wherein the length of the arrow is made to be proportional to the strength of the field and the direction of the arrow is the same as that of the field's. Use arrows to sketch each of the following vectors fields:

(i) $\vec{E} = -y\hat{x}$

(ii) $\vec{B} = \hat{\phi}$ [4 + 4 marks]

(c) Transform vector, $\vec{Q} = (y - x)\hat{x} + (x - y)\hat{y}$ into cylindrical coordinates and then evaluate it at the point A(2, 0, 2). [6 marks]

(d) Sketch the outlines of the surface: $2 \leq r \leq 5, \pi/2 \leq \phi \leq \pi, z = 0$. Determine the area of the surface with the cylindrical coordinate system. [6 marks]

Question 2

(a)(i) State the Coulomb's law. [3 marks]

(ii) Write the electric field due to multiple point charges. [4 marks]

(b) Three point charges, each with $Q = 2$ nC are located at the corners of a triangle in the x-y plane with one corner at origin, another at (2 cm, 0, 0), and the third at (0, 2 cm, 0). Find the force acting on the charge located at the origin. [6 marks]

(c) Show that the electric potential difference V_{12} between two points in air at radial distances r_1 and r_2 from an infinite line of charge with density ρ_l along the z-axis is $V_{12} = \frac{\rho_l}{2\pi\varepsilon_o} \ln(\frac{r_2}{r_1})$. [6 marks]

(d)(i) Give the expression of capacitance for a parallel-plate capacitor. [3 marks]

(ii) What is the total capacitance of two capacitors connected in parallel? [3 marks]

Continued .....

Question 3

(a) A stationary conducting loop with internal resistance of 0.5 Ω is placed in a time-varying magnetic field. A current of 2 A flows through it when the loop is closed. What will the current be if the loop is opened to create a small gap and a 2 Ω resistor is connected across its open ends? [5 marks]

(b) Given the magnetic field due to wire carrying the current I at the distance r is $\vec{B} = \frac{\mu_o I}{2\pi r}\hat{\phi}$. Find the magnetic force between the two long, straight, parallel wires in free space, separated by a distance d and carrying currents I_1 and I_2 in the same direction. [6 marks]

(c)(i) Give the expression of Ampere's law. [2 marks]

(ii) Use the Ampere's law, find the magnetic field intensity, $\vec{H}$ due to the current $I = 3$A in Figure Q3. [3 marks]

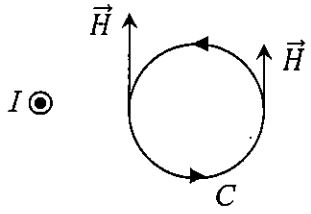

Figure Q3

(d)(i) Describe the structure of a solenoid as a typical inductor. [3 marks]

(ii) What is the self-inductance of a conducting structure? [3 marks]

(iii) The magnetic flux linkage Λ for a solenoid with N turns is given as $\Lambda = \mu\frac{N^2}{l}IS$ (Wb), where S is the cross-sectional area of the loop, I is the current and l is the solenoid length. Determine the self-inductance expression of this solenoid. [3 marks]

Continued .....

Question 4

(a) Typical magnetic materials are classified according to the nature of their response to a magnetizing field. Give the explanation on ferromagnetic materials. [4 marks]

(b) Michael Faraday conducted an experiment in year 1831 to show the electric fields are produced by time-varying magnetic fields. List two methods to demonstrate Faraday's law of induction. [6 marks]

(c) Eddy currents are usually undesirable in transformers and motors because they produce ohmic losses. Suggest a common method to reduce the eddy current loss in ferromagnetic cores. [4 marks]

(d)(i) What is meant by *reluctance* in the magnetic circuit? [4 marks]

(ii) An iron ring of mean radius 200 mm is wound with 80 turns of wire. Given the magnetic flux density, B = 0.5 T and relative permeability, μ_r = 250, find the current flows in the wire. [7 marks]

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FORMULAE

Transformation	Coordinate Variables	Unit Vectors	Vector Components
Cartesian to Cylindrical	$r=\sqrt{x^2+y^2}$ $\phi=\tan^{-1}(y/x)$ $z=z$	$\hat{r}=\hat{x}\cos\phi+\hat{y}\sin\phi$ $\hat{\phi}=-\hat{x}\sin\phi+\hat{y}\cos\phi$ $\hat{z}=\hat{z}$	$A_r=A_x\cos\phi+A_y\sin\phi$ $A_\phi=-A_x\sin\phi+A_y\cos\phi$ $A_z=A_z$
Cylindrical to Cartesian	$x=r\cos\phi$ $y=r\sin\phi$ $z=z$	$\hat{x}=\hat{r}\cos\phi-\hat{\phi}\sin\phi$ $\hat{y}=\hat{r}\sin\phi+\hat{\phi}\cos\phi$ $\hat{z}=\hat{z}$	$A_x=A_r\cos\phi-A_\phi\sin\phi$ $A_y=A_r\sin\phi+A_\phi\cos\phi$ $A_z=A_z$
Cartesian to Spherical	$R=\sqrt{x^2+y^2+z^2}$ $\theta=\tan^{-1}(\sqrt{x^2+y^2}/z)$ $\phi=\tan^{-1}(y/x)$	$\hat{R}=\hat{x}\sin\theta\cos\phi$ $+\hat{y}\sin\theta\sin\phi+\hat{z}\cos\theta$ $\hat{\theta}=\hat{x}\cos\theta\cos\phi$ $+\hat{y}\cos\theta\sin\phi-\hat{z}\sin\theta$ $\hat{\phi}=-\hat{x}\sin\phi+\hat{y}\cos\phi$	$A_R=A_x\sin\theta\cos\phi$ $+A_y\sin\theta\sin\phi+A_z\cos\theta$ $A_\theta=A_x\cos\theta\cos\phi$ $+A_y\cos\theta\sin\phi-A_z\sin\theta$ $A_\phi=-A_x\sin\phi+A_y\cos\phi$
Spherical to Cartesian	$x=R\sin\theta\cos\phi$ $y=R\sin\theta\sin\phi$ $z=R\cos\theta$	$\hat{x}=\hat{R}\sin\theta\cos\phi$ $+\hat{\theta}\cos\theta\cos\phi-\hat{\phi}\sin\phi$ $\hat{y}=\hat{R}\sin\theta\sin\phi$ $+\hat{\theta}\cos\theta\sin\phi+\hat{\phi}\cos\phi$ $\hat{z}=\hat{R}\cos\theta-\hat{\theta}\sin\theta$	$A_x=A_R\sin\theta\cos\phi$ $+A_\theta\cos\theta\cos\phi-A_\phi\sin\phi$ $A_y=A_R\sin\theta\sin\phi$ $+A_\theta\cos\theta\sin\phi+A_\phi\cos\phi$ $A_z=A_R\cos\theta-A_\theta\sin\theta$
Cylindrical to Spherical	$R=\sqrt{r^2+z^2}$ $\theta=\tan^{-1}(r/z)$ $\phi=\phi$	$\hat{R}=\hat{r}\sin\theta+\hat{z}\cos\theta$ $\hat{\theta}=\hat{r}\cos\theta-\hat{z}\sin\theta$ $\hat{\phi}=\hat{\phi}$	$A_R=A_r\sin\theta+A_z\cos\theta$ $A_\theta=A_r\cos\theta-A_z\sin\theta$ $A_\phi=A_\phi$
Spherical to Cylindrical	$r=R\sin\theta$ $\phi=\phi$ $z=R\cos\theta$	$\hat{r}=\hat{R}\sin\theta+\hat{\theta}\cos\theta$ $\hat{\phi}=\hat{\phi}$ $\hat{z}=\hat{R}\cos\theta-\hat{\theta}\sin\theta$	$A_r=A_R\sin\theta+A_\theta\cos\theta$ $A_\phi=A_\phi$ $A_z=A_R\cos\theta-A_\theta\sin\theta$

Permittivity of free space, $\varepsilon_o=8.854\times10^{-12}\,F/m$

Permeability of free space, $\mu_o=4\pi\times10^{-7}\,T.m/A$

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